Incidence and circumstances of falls among middle-aged women: a cohort study

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Mini-Abstract

This was the first study assessing falls prospectively in middle-aged women. The one-year incidence was 42% for any fall, which suggest falls are a major issue in middle-aged women. Middle-aged women, particularly those sustaining a fall, could be a target group for falls prevention strategies.

Abstract

Purpose: Incidence and circumstances of falls in middle-aged people are poorly understood. This cohort study aimed to elucidate the incidence and circumstances of falls over one year in middle-aged women.

Methods: Falls were recorded monthly for one year by questionnaire in 2017-2019 in a population-based sample of women aged 41-62 years. The incidence of falls and injurious falls, and related circumstances were descriptively analysed.

Results: Of 273 women, 115 sustained 209 falls. The one-year incidence was 42% for any fall, 17% for multiple (two or more) falls, and 24% for injurious falls. The incidence was greater in older age groups for any fall (33%, 45% and 44% for people aged <50, 50-55, and >55 years, respectively), multiple falls (7%, 14%, and 22%) and injurious falls (15%, 20%, and 28%), although only the incidence of multiple falls was significantly increased across the three age groups (P=0.01). Most falls occurred outdoors (71%) and were attributed to tripping and slipping (60%).

Conclusions: Falls are a major issue in middle-aged women, a group that has been largely ignored in the prevention of falls. Middle-aged women, in particular those sustaining a fall, could be a target group for falls prevention strategies. Future studies are needed to identify risk factors for falling in this population so as inform the development of strategies for preventing falls in middle-aged women.

Keywords: descriptive analysis, injury, location, cause, longitudinal study

Introduction

Falls are a major public health issue among older people, being the second leading cause of unintentional injury-related mortality worldwide [1]. Around thirty to forty percent of community-dwelling persons over the age of 65 fall each year [2,3] and women have a higher risk than men [4]. Retrospective data suggest that falls may occur at a similar rate in middle-aged and older people [5], but this has not been confirmed with prospective data and the incidence and circumstances of falls in this age group is poorly studied. Nonetheless, the disability-adjusted life years (DALYs) caused by falls in middle-aged adults is estimated to be 10620 thousand worldwide [6]. Because a previous fall is one of the strongest risk factors for future falling [4], preventing falling in middle age may also help to prevent falls in older age.

Previous studies of falls in middle-aged adults have only assessed prevalence of falls retrospectively over periods ranging from the previous 3 months to two years, with the prevalence ranging from 12 to 25% [5,7-9]. However, these retrospective data are subject to recall bias [10], that can lead to substantial underestimation of the rate of falls, by up to 32.8% [11]. To that end, prospective recording of falls at least once a month over 6 to 12 months is recommended by the Prevention of Falls Network Europe and Outcomes Consensus Group [12,13]. However, no studies have assessed the incidence and circumstances of falls measured prospectively in middle-aged women. Addressing this evidence gap could help develop tailored prevention strategy for falls in this age group of women. Therefore, the aim of our study was to describe the incidence and circumstances of falls over one year in middle-aged women.

Methods

Participants

This is a one-year prospective cohort study assessing falls in middle-aged women between 2017-2019. Participants were recruited from 470 women who were randomly selected from the

Tasmania electoral roll and participated in a 2-year randomised controlled trial (RCT) of an osteoporosis education intervention in 2000 [14,15] who were further followed up in 2011-2012 [16]. We invited all women who participated in the 2011-2012 follow-up (n=347) to participate in the current study. The details of the original RCT and 2011-2012 follow-up study have been described elsewhere [14-16]. The study did not include any education around falls. Briefly, participants were excluded from the original RCT if they had: previous measurement of bone density, thyroid disease, renal failure, malignancy, rheumatoid arthritis, a history of hysterectomy or hormone replacement therapies, pregnancy or planning pregnancy within 2 years of study entry, or were lactating. This study was approved by the Tasmania Health and Medical Human Research Ethics Committee (H0016156), and all participants gave written informed consent.

Measurement of falls

A fall was defined as 'an unexpected event in which the participant comes to rest on the ground, floor, or lower level'[13]. Incidence of falls was assessed monthly for 12 months by questionnaire. The questionnaire asked if the participant had any falls in the month, and if yes, the dates, location and any reason of the fall(s), and any injuries from the fall(s). An injurious fall was defined as at least one fall that caused any injuries in the month. They were asked to record any fall for each month. Participants were given three months of questionnaires at a time and returned them via a pre-paid envelope. If questionnaires were not returned within two weeks of the end of each three months, a research assistant phoned participants to confirm if there were any falls.

Anthropometric and other factors

Height was measured to the nearest 0.1 centimetre (cm) by a stadiometer (The Leicester height measure, Invicta Plastics Ltd, Oadby, England), with shoes, socks, and headgear removed.

Weight was measured to the nearest 0.1 kilogram (kg) by a single set of calibrated scales (Heine, Dover NH USA) with shoes and heavy clothing removed. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2).

We used a standardised questionnaire to collect education level (4 point scale: less than grade 10, up to grade 10, completed grade 12, tertiary), smoking history (current/former/never), marital status (single, married and living together, married but separated, unmarried but living together, divorced), hours of employment (0, less than or equal to 20 or >20 hours per week) , family history of osteoporosis and fracture/broken bone, history of fractures in the participant, use of oral contraceptive, and menopausal status (post-menopause, pre-menopause, not clear, peri-menopause).

Statistical analyses

The characteristics of participants are presented using mean (standard deviation, SD) for continuous variables, and number (%) for categorical variables. We compared the characteristics of participants with and without falls by using *chi*-squared or Fisher's exact test for categorical variables as appropriate, and Student's *t*-test for continuous variables. We were interested in potential differences in falls in those aged <50 years, 50-55 years and older than 55 years as 1) age 50-55 years is a stage when people begin to pass from middle to old age, especially with menopause in women [17]; 2) balance and muscle strength begin to decline sharply after 45-55 years [18,19]. However, because of the age distribution of participants, we were only able to meaningfully categorise the falls data by three age groups (<50, 50-55, >55 years). The incidence of any fall, multiple falls and injurious falls and the frequency distributions of location, causes, and season of falls for these three age groups were presented as number (%). To examine the increasing trend towards the incidence of falls across the three age groups, Wilcoxon Rank Sum test was used. The differences in the three age groups

regarding the circumstances of falls were tested using *chi*-squared or Fisher's exact test as appropriate. A two-sided *P* value <0.05 was considered statistically significant. All statistical analyses were conducted using Stata version 16.0 (Stata Corp, College Station, TX, USA).

Results

Characteristics of the participants

In recruiting for the original 2-year randomised controlled trial, 470 of 739 eligible women invited agreed to participate (response rate of 64%, aged 25-44 years) [15]. Three withdrew prior to intervention delivery and were not included in subsequent analyses [15]. Two hundred and seventy-eight were retained in the 2017-2019 follow-up (aged 41-62 years). Five of these recorded no falls data, so, 273 participants were included in the present analysis. Of these, all but two completed one-year recording of falls data - these two participants completed 6-months and10-months, respectively. The differences in baseline characteristics of the participants who were (n=273) and were not (n=194) included in the current study are shown in Supplementary Table 1 (Online Resource). Participants lost to 2017-2019 follow-up were younger, shorter, less educated, more likely to be former/current smokers compared with those who were included in the present study (*P*<0.05 for all). Other characteristics were similar.

Table 1 shows study participants' characteristics of the total sample and for fallers and non-fallers. The characteristics of fallers and non-fallers were similar, except that the proportion of non-smokers and of participants who were unemployed was higher in fallers (72 vs 59% *P*=0.007 and 22 vs 17%, *P*=0.046, respectively). Fallers were only slightly older than non-fallers and the difference was not statistically significant (Table 1) but multiple fallers (mean age 56.9 (SD 3.9) years) were older than non-multiple fallers (54.8 (SD 5.3) years) (*P*=0.009).

Incidence of falls and injurious falls by age group

The incidence of falls and injurious falls by age group is presented in Table 2. There were 209 falls. Forty-two percent of participants (n=115) suffered at least one fall (any fall), 17% suffered multiple falls, and 24% suffered injurious falls (Table 2).

The incidence of falls, multiple falls and injurious falls was greater in older age groups, though the difference across age groups was only statistically significant for multiple falls (p=0.25, 0.01 and 0.05 for any fall, multiple falls and injurious falls respectively). Thirty-three percent of participants aged <50 years sustained at least one fall, rising to 45% in those aged 50-55 years, and 44% in those aged >55 years. The incidence of multiple falls was 7% in participants aged <50 years, 14% in those aged 50-55 years, and 22% in those aged >55 years. In addition, the incidence of injurious falls was 15% in participants aged <50 years, 20% in those aged 50-55 years, and 28% in those aged >55 years.

Circumstances of falls by age group

Location and causes

A summary of the location of falls is presented in Figure 1. Falls were more likely to occur outdoors than indoors (71% and 29% respectively). The proportion of falls occurring outdoors was similar across the three age groups (71%, 67%, and 72% in people aged <50, 50-55, and >55 years, respectively) (*P*=0.74).

The causes of falls are presented in Table 3. There were 230 causes reported for the 209 falls (11 falls had two or more causes). The commonest reported causes were tripping and slipping, accounting for 60% (35% and 25%, respectively), followed by environmental hazards (13%) and loss of balance (11%). Tripping and slipping were reported more frequently with age rising from 47% in those aged <50 years, to 62% and 61% in those aged 50-55 years and >55 years respectively. However, these differences were not statistically significant.

Proportion of falls in each season

The distribution of falls among the four seasons is shown in Figure 2. Overall, the proportion of falls was slightly higher in summer (29%, 59 falls) and autumn (27%, 56 falls), compared to spring (22%, 47 falls) and winter (22%, 47 falls). There were statistical differences between the three age groups in the distribution of falls among four seasons; a higher proportion of falls in summer and autumn in those aged 50-55 (39% and 31%) and >55 (24% and 29%) years compared to that in those aged <50 years (11% and 11%) (P=0.03).

Discussion

Our study provides new data about the incidence and the circumstances of falls in middle-aged women. The incidence of any, multiple and injurious falls was high (42%, 17%, and 24%, respectively) and was greater in older age groups, although the increase with age was only statistically significant for those with multiple falls. Most falls occurred outdoors and were mainly caused by tripping and slipping. These findings suggest that falls are a major issue in middle-aged women, a group that has been largely ignored in the prevention of falls. Middle-aged women, particularly those sustaining a fall, could be a target group for falls prevention strategies. They also highlight the importance of future studies to identify risk factors for falling so as inform the development of strategies for preventing falls in middle-aged women. Such an approach may also help to prevent falls in old age.

Incidence of falls

The incidence of any fall in the current study was similar to that in prospective studies in older adults [2,3,20] and even higher than in retrospective studies in that population [21-23]. This suggests that falls are a major issue in middle-aged women, and this has not been well recognised in research or clinical practice. The few cross-sectional studies in middle-aged people have reported a wide range of falls rates, ranging from 2.5% to 31.6% assessed retrospectively over the past 3 months to 2 years [24,9,25,26]. This retrospective assessment

could be the main reason for the lower rates in these studies than ours, as the potential recall bias of the retrospective method could result in underestimation of the rate of falls by up to 32.8% compared to prospective methods [11]. Other reasons may also explain the variability in rate of falls between studies. For example, Hong et al. [26] reported a very low rate of falls of 2.5% during the past 2 years in Koreans aged 45-64 years (about 50% females), but of note falling is usually understood by Koreans as the body falling from a higher position to a lower position, without including slipping, sliding down and sitting down because of a missed steps [26]. In addition, about half of the participants in the study by Hong et al. were males [27], who are less likely to fall than females [24].

Similarly, the incidences of multiple falls and injurious falls were also higher than in previous cross-sectional studies. These reported the percentage of participants who experienced multiple falls and injurious falls in middle-aged adults during the past 2 years as approximately 7-9% and 6-15% respectively [7,9]. Again, the use of retrospective falls assessment in these studies could have led to underestimation, but one study also applied a stricter definition of injurious falls [9]. Older people with multiple falls are more likely to have gait, cognitive, neurological, physiological and muscle-skeletal problems which predispose them to falling, compared to infrequent fallers [2,20,28]. However, it is currently unknown if this is the case for those in middle age and further research is needed to understand risk factors for multiple falls in middle-aged women. In older adults, multiple fallers considered a high-risk group that should be targeted for prevention of further falls [29]. This may also be the case in middle-aged women but further research is needed to confirm the how best to approach this and the effectiveness of intervening.

Greater incidence of falls with age

The incidence of any, multiple and injurious falls was greater in older age groups. The differences were of sufficient magnitude to be of clinical and public health relevance (around a 50% higher incidence of any fall after age 50 years, and a tripling and doubling of incidence by age >55 years for multiple falls and injurious falls respectively) although only statistically significant in multiple fallers. The small numbers of women in the younger age groups (n=46 and 65) limited the power of the study to detect age-related differences. Nonetheless, falls incidence was high even in the younger age groups. It might be that better-functioning younger people were also at higher risk of falls due to engagement in greater level of sporting or ambulatory activity, as has been found in prior studies of older people [30]. In contrast to any fall which had a similarly higher incidence in those aged 50-55 and >55 years old, the incidence of multiple and injurious falls was higher across all three age groups. Because multiple falls are more likely to be associated with poorer neurological, gait, cognitive, physiological and musculoskeletal function [28,2,20], the increasing incidence of multiple falls with age might suggest a large influence of age-related decline of functional capabilities on the risk of falling. In line with the observation that multiple falls are usually associated with injuries [31], there was a similar age-related pattern of the incident injurious falls. Given the clinical importance of injuries sustained from falls, it is critical to prevent this increasing trend of the incidence of multiple and injurious falls with ageing. A better understanding of the risk factor profiles for different categories for falls in younger women is essential to accomplishing this.

Circumstances of falls

Falls are less likely to occur outdoors with advancing age in older people [32,33]. In contrast, we did not observe an age-related difference in the proportion of falls occurring outdoors. The proportion of 71% of falls occurring outdoors in the present study is comparable with a previous study of middle-aged adults [7], while somewhat higher than those of studies in older adults (e.g. 50%) [32]. There is evidence that indoor falls are more likely to be associated with

frailty whilst outdoor falls tend to be partly explained by higher physical activity [34]. This is consistent with our findings that the proportion of falls is slightly higher in Summer and Autumn, when people would undertake more outdoor activities. Thus, the high percentage of outdoor falls in our study might be indicative of a high level of outdoor activity in middle-aged adults and a lesser likelihood of frailty. In addition, we detected sports-related falls and animal-related falls, which might indicate a high level of outdoor activities in our population. With the widespread promotion of an active lifestyle by various health organizations [35-37], ensuring the safety of outdoor activities should be a priority. For example, by properly maintaining sidewalks, curbs, and other outdoor pedestrian spaces, the likelihood of falls can be reduced [34]. Furthermore, pre-sporting assessment of muscle strength and balance appropriate for the sport, as well as good osteoporosis screening and management [29] may assist in reducing injurious falls.

Most falls were due to tripping and slipping, particularly in women aged 50 years and over, followed by environmental hazards (for example uneven surfaces or loose gravel) and loss of balance. Although we were not able to identify the causes of tripping and slipping, they seem to be most likely to also be due to environmental factors, such as slopes, obstructed or uneven pathways and ramps [38]. To date, only one community-based cross-sectional study in middle-aged women [7], has investigated environmental factors, reporting that uneven surface/steps contributed to the highest percentage of falls. In fact, environmental reasons for falls were cited more frequently in middle-aged adults (30.2%) compared to older adults (15.8%) [7]. This further supports the premise that environmental factors may play an important role in the high incidence of falls in middle-aged women. Nonetheless, further research with falls measured prospectively that includes more detailed examination of the circumstances of falls in middle-aged women would confirm this and further assist in defining the types of hazards that pose the greatest risk.

Strengths and Limitations

The key strengths of this study are the use of monthly questionnaires to prospectively ascertain the incidence of falls in an under-investigated population - middle-aged women. The study also has several potential limitations. The number of injurious falls might be underestimated because we did not specifically ask whether participants reporting two falls in a month suffered from injuries from one fall or both. However, as this occurred in only four participants this is unlikely to materially affect our results. Detailed information about circumstances were not collected, including specific locations of falls, activities and the purposes of the activities at the time of falling. These details may provide further information about the reasons of fall-related injuries to inform prevention strategies. In addition, the types of fall-related injuries were not asked, and we were not able to evaluate the severity of the consequences of falls, which is important to assess the clinical significance especially for those injuries leading to hospitalisation. Thus, longitudinal studies with more detailed information of falls are required to explore environmental aspects and consequence of falls in middle-aged adults. Selection bias might exist due to the 64% response rate at recruitment. However, as previously reported, although the proportion of current smokers (17%) in the sample was lower than the Tasmanian prevalence of daily smoking (29%) in women aged 25-44 years in 1998, socioeconomic factors like educational level and unemployment rate approximate the overall population figures [15]. Therefore, the original sample is likely to be representative of the general population of that age range in South Tasmania. Another potential limitation is missing data due to drop-out. The women who were lost to follow-up were younger, shorter, less educated and more likely to be former/current smokers compared to those who completed the study and so perhaps more likely to be less healthy than those who participated in this study. This suggests that if anything loss to follow-up might lead to an underestimation rather than overestimation of falls incidence in middle-aged women.

Conclusions

Falls are a major issue in middle-aged women, a group that has been largely ignored in the prevention of falls. Middle-aged women, especially those sustaining a fall, could be a target group for falls prevention strategies. The results also highlight the importance of future studies to identify risk factors for falling in this population so as inform the development of strategies for preventing falls in middle-aged women. Such early intervention may also be beneficial for preventing falls in later life.

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical Standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Conflict of interest

Mengmeng Wang, Feitong Wu, Michele L. Callisaya, Graeme Jones, and Tania Winzenberg declare that they have no conflict of interest.

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Table 1 Characteristics of the participants

	Total (n=273)	Subgroups by Falling		*P* value[c]
		Faller (n=115)	Non-Faller (n=158)	
Age(years)	55.2 (5.1)	55.4 (4.9)	54.9 (5.3)	0.44
Height (cm)	164.0 (6.4)	164.3 (6.4)	163.8 (6.4)	0.55
Weight (kg)	74.8 (16.1)	74.8 (15.8)	74.8 (16.3)	0.98
Body mass index (kg/m^2)	27.8 (5.9)	27.8 (5.8)	27.9 (6.0)	0.87
Education, n (%)[a]				0.07
Primary/High school	76 (28)	24 (21)	52 (33)	
High school/college	59 (22)	25 (22)	34 (22)	
University, CAE, or other tertiary institution	138 (50)	66 (57)	72 (45)	
Smoking, n (%)[b]				0.007*
Never	176 (65)	83 (72)	93 (59)	
Current smoker	19 (7)	2 (2)	17 (11)	
Ex-smoker	77 (28)	30 (26)	47 (30)	
Married/defacto, n (%)	215 (79)	97 (84)	118 (75)	0.07
Employed, n (%)[b]				0.046*
No	51 (19)	25 (22)	26 (17)	
<20hours per week	46 (17)	12 (11)	34 (22)	
>20hours per week	172 (64)	76 (67)	96 (61)	
Family history of osteoporosis, n (%)	112 (41)	51 (45)	61 (39)	0.30
Family fracture/broken bone, n (%)	184 (68)	84 (74)	100 (64)	0.08
History of fracture, n (%)	36 (13)	15 (13)	21 (13)	0.94
Ever use of oral contraceptive, n (%)	261 (96)	109 (95)	152 (97)	0.54
Menopause, n (%)[b]				0.20
Postmenopause	148 (54)	70 (61)	78 (50)	
Premenopause	51 (19)	20 (17)	31 (20)	
Not clear	18 (7)	8 (7)	10 (6)	
Perimenopause	55 (20)	17 (15)	38 (24)	

Note. Values are presented as Mean (standard deviation) unless otherwise stated. [a] Primary school/high school (left before the end of grade 10/completed to the end of grade 10); high school/college (completed to the end of grade 12); university, College of Advanced Education (CAE), or other tertiary institution. [b] Numbers in the "Total" column do not always equal to 273 due to a small number of missing values. [c] *P* values are for difference in fall status by *chi*-squared or Fisher's exact tests for categorical variables, and Student's *t*-tests for continuous variables. *denotes statistically significant ($P<0.05$).

Table 2 Number (percentage) of people reporting falls by age group during one-year follow-up (n=273)

	Total population		Subgroups by age					
			<50 years (n=46)		50-55 years (n=65)		>55 years (n=162)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Number of falls								
0	158	58	31	67	36	55	91	56
1	68	25	12	26	20	31	36	22
2	31	11	3	7	6	9	22	14
3	3	1	0	0	0	0	3	2
4	7	3	0	0	1	2	6	4
≥5	6	2	0	0	2	3	4	2
Number of injurious falls								
0	208	76	39	85	52	80	117	72
1	55	20	7	15	11	17	37	23
≥2	10	4	0	0	2	3	8	5
Total	273	100	46	100	65	100	162	100

Table 3 Causes of falling among fallers by age group

Causes	Total population		Subgroups by age					
			<50 years (n=46)		50-55 years (n=65)		>55 years (n=162)	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Tripped	80	35	4	21	17	33	59	37
Slipped	58	25	5	26	15	29	38	24
Lost balance	25	11	2	11	1	2	22	13
Legs gave away	3	1	0	0	0	0	3	2
Feel faint	3	1	1	5	1	2	1	1
Feel giddy/dizzy	0	0	0	0	0	0	0	0
Others								
Animal-related	5	2	0	0	3	6	2	1
Sports/activities	16	7	1	5	5	10	10	6
Medical condition	5	2	1	5	3	6	1	1
Environmental hazards	28	13	4	22	4	8	20	12
Being knocked over	4	2	0	0	1	2	3	2
Rolled ankle/give away knee (no detailed reason given)	3	1	1	5	1	2	1	1
Total	230	100	19	100	51	100	160	100

Note. 230 causes for 209 falls. The number of causes is larger than the number of falls as some participants gave more than one reason for each fall. The category of causes for falling includes five options (tripped, slipped, lost balance, legs gave away, feel faint, feel giddy/dizzy) and one open answer (others). When participants thought the five options did not fit the reason of their falling, they wrote the specific reason on the item of "others" (*Of "others", environmental hazards refer to falls that were caused by unsafe surrounding such as uneven surface or loose gravel; animal-related refers to walking the dog or being pushed over by a dog or other animals*).

There was no statistical difference in the three age groups by *chi*-squared test for causes of falling (χ^2 =2.63, *P*=0.62) (*Lost balance, legs gave away, feel faint, feel giddy/dizzy, and others are combined as one category due to the small sample size of these causes when conducting chi-squared test*).

Figure captions

Fig. 1 The location of falls by age group

Fig. 2 The proportion of falls in each season by age group

The study was carried out in the southern hemisphere, so spring is from September to November, summer is from December to February, autumn is from March to May and winter is from June to August.